Design, Development and Evaluation of VirtualAlps 2.0:

A Semantic Web Based Virtual Field Guide for teaching Level 6 Geoscience

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***Abstract*— This paper draws on experiences of designing, developing, using and evaluating a semantic web-based Virtual Field Guide (VFG), VirtualAlps 2.0, for teaching geosciences. The paper briefly reviews the previous use of VFGs to support students' learning by fieldwork, highlighting some benefits. VFGs are considered to supplement real fieldwork, but not to become a substitute for it. We then outline the design considerations, development and staff and student evaluation of the Virtual Alps 2.0 VFG developed for level 6 undergraduates. The design and development of Virtual Alps 2.0 was undertaken by experts who were part of the Ensemble Project at Liverpool John Moores University. This paper describes the development of a pilot VFG which employs 'linked data' and 'semantic web' approaches to allow students to access diverse web-based resources, to explore the relations between them, and to then draw on these in the course of more authentic assessment activities than has hitherto been the case.**

The new assessment for which the VFG was developed, required students to assess the social, environmental and economic costs and benefits of a proposed hydro-electric reservoir in a Swiss Alpine Valley. The VFG provided students with real environmental data, maps, photographs, video and links to relevant research papers which students used to make interpretations and draw their conclusions about the feasibility of such a scheme.

Their answers were then subjected to analysis and students' work from the assessment task based on VirtualAlps 2.0 demonstrated a wider range of skills (performing calculations, drawing graphs & diagrams themselves, creating more tabulations and making more opinions/decisions) than in a traditional essay which had been the assessment task set in previous years. This study shows the potential to use specifically designed interactive 'Web 2.0' innovations to enhance students' decision making skills in an assessment which we argue prepares them better for employment. Geoscience and the world of employment for geoscientists is in a state of flux at present, and the ability to work using linked data and semantic web approaches is now an important skill for graduates to be able to offer.

Keywords-fieldwork; virtual field guide; decision making; student assessment; skill acquisition; emplyoment

I. INTRODUCTION

The benefits of teaching and learning through fieldwork have long been recognised by educators in schools and universities [1] and the notion of supporting fieldwork with web-based and mobile technologies in the Geography, Earth and Environmental Science (GEES) disciplines has been gaining interest over the past decade [2]. Virtual environments and e-learning resources have been shown to help students become active rather than passive learners by appealing to their multi-sensory learning ability with interactive media [3].

While the provision of actual fieldwork (organized visits to specific sites) in the curriculum is still a priority for many higher education institution (HEI) geoscience programmes, 'Virtual Field Guides (VFGs) can allow students to gain prior and subsequent examination of field sites [4]. Students have time beforehand to familiarise themselves with the field visit location and tasks on-line before the visit, so that they know what to expect when they arrive. The opportunity to plan and practice field skills by using the VFG before a visit may improve students' confidence and help them overcome any anxieties [5].

VFGs also allow students to review and evaluate their experience after a visit, to process information and even link field sites or other resources [6]. In addition, VFGs can encourage users to make links between elements of courses, for example by integrating aerial images and environmental data to help explain features and processes observed in the field (e.g. extent of landforms, river planforms etc). VFGs can also provide some compensation when adverse weather prevents some aspects of the intended field visit being completed; when time constrains a more thorough investigation of field sites; or when students' mobility may limit access.

Widening access for those with learner support needs in HEIs is a priority and the use of VFGs can ensure that temporarily absent or distance learning students do not suffer academically as a result of missing key components of a course or degree which involves fieldwork VFGs, when made available to the wider public, can allow students of geosciences, or school age students contemplating study of the geosciences in higher education, not only to gain access to representations of different field environments, but also to gain an understanding of the fieldwork approaches and techniques in which they might be engaged during future study or in professional practice.

II. DESIGN AND DEVELOPMENT OF VIRTUALALPS 2.0

A. *Background to the Design*

Since 2001 Liverpool John Moores Unversity staff had been designing virtual field guides and incorporating them into the geoscience teaching. Examples included the Ingeton Waterfalls Trail [7], and Virtual Alps [8, 9, 10]. The 'Ensemble' project was a UK-based research project funded by the Economic and Social Research Council (ESRC) and the Engineering and Physical Sciences Research Council (EPSRC) as part of its Technology-Enhanced Learning Research Programme (http:// http://www.tel.ac.uk/). The project was launched in 2008 with the intention to explore how new web technologies could support and enhance various forms of 'case based' learning. At Liverpool John Moores University the decision was made to redevelop the existing 'Virtual Alps' VFG [8], drawing on linked, open data and data that research in the field had previously collected [e.g. 11]. The aim of the new design was to foster more ‘expert-like’ reasoning among final-year students, and to make a final year assessment task have more ‘authenticity’ and relevance to the work of work which they would be entering. To this end, metadata records for each of the items were created (so that, for example, the content of images or journal papers was described in a metadata record rather in the web page in which the image or journal link happened currently to be displayed). The glossary that already existed as part of the VFG was restructured so that it could be used as the basis of keywords attached to each image, video clip or data set in the Virtual Alps collection. The 'Exhibit' web application framework developed at the Massachusetts Institute of Technology as part of the SIMILE project (http://simile.mit.edu) [12], was developed by the Ensemble project and applied to meet this task. Further details about the Ensemble project and the rationale behind the design and development are given in [13] while the underpinning pedagogical principles are developed in [14].

B. *VirtualAlps 2.0*

VirtualAlps 2.0 provided students with something that was sufficiently familiar that they could easily engage with it, but also addressed the teacher's intention that students develop skills in manipulating, analysing and interpreting diverse data (e.g. excel files, video clips, journal readings, photographic images), rather than simply further building confidence in procedural tasks which the existing assessment, an essay, requested. The designers suggested associations between the different types of data so that students would be able to use the ‘faceted browsing’ and visualisation tools to explore these links. Thus, the academic request envisaged by the tutor would still be inherent in the construction of the site, but was no longer as evident or explicit. There was shift in thinking from ‘what students would see’ to ‘what students would do’. So, a linear, procedural task was replaced by an environment in which students could select data and other resources, and thus tentatively develop certain avenues of enquiry whilst temporarily excluding others.

The 'Virtual Alps 2.0' VFG home page is shown in Figure 1. Figure 2 shows the VirtualAlps 2.0 Hydro-Electric Power Case Study page. which outlines the open-ended task which asks students to consider the best location for a dam, reservoir and Hydroelectric Power (HEP) plant in the Morteratsch Valley in the Bernina Alps, Switzerland, and the consequences of its construction. The data, images, video and published papers that have potential relevance to this task are then presented with some structure and direction (with links suggesting 'these resources may be useful in deciding …') and students are able to view these and decide whether to incorporate them into their solution to the problem task.

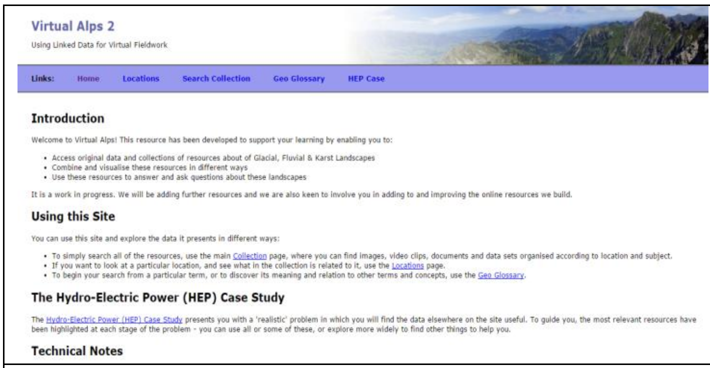

Figure 1: VirtualAlps 2.0 Home page. http://redtech.ljmu.ac.uk/projects/virtualalps/index.html, accessed 26-6-15

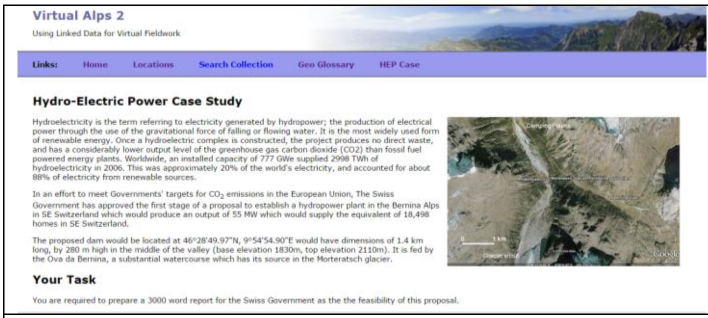

Figure 2: VirtualAlps 2.0 Hydro-Electric Power Case Study http://redtech.ljmu.ac.uk/projects/virtualalps/hep_case.html, accessed 26-6-15

III. EVALUATION OF VIRTUALALPS 2.0

A. *Gathering the data*

The change in the module assessment task allowed a comparison of students’ answers before and after the change.

Prior to 2013 the assessment task was an essay (1500 words) with the title: “Discuss the impacts of current trends in climate on river flood hazards”. A total of 22 student essays from 2013 were analysed during the marking process and counts were made of the number of: graphs/figures drawn; maps; diagrams sourced; photographs; tables compiled; calculations; opinions expressed; journals cited; books/reports cited; and, websites cited. Table I summarises these statistics.

In 2014 VirtualAlps 2.0 was used and the assessment task was changed to a 1500 word report for the Swiss Government on: “Use the Virtual Field Guide Resource to prepare an environmental impact assessment of a hydro-electricity project in a Swiss Alpine valley". A total of 21 student reports from 2014 were analysed during the marking process and again counts were made of the number of: graphs/figures drawn; maps; diagrams sourced; photographs; tables compiled; calculations; opinions expressed; journals cited; books/reports cited; and, websites cited. Table II summarises these statistics.

TABLE I: RIVER FLOODING & CLIMATE CHANGE ESSAY CONTENT STATISTICS FOR STUDENTS IN 2013

	River flooding	& climate change									
	Graphs/Figs drawn	Maps	Diagrams sourced	Photos	Tables compiled	Calculations	Opinions	Journals cited	Books/ Reports cited	Websites cited	FINAL MARK
Student01		2		1				9	1	3	61
Student02			4	2				1	4	4	49
Student03			9	2				13	5	4	77
Student04			7	2				12	3	0	62
Student05			1					4	1	2	50
Student06		1	3	4				15	1	4	77
Student07			4	3	1			8	3	5	70
Student08			1	5				6	6		57
Student09			2	1				11	4	1	79
Student10			3	1				6	6	2	79
Student11		2	4					8	3	16	76
Student12		1	4					10	3	4	67
Student13			6	1				12	6	3	74
Student14		2	2	4				10	5		72
Student15			2	4				7	3	2	63
Student16			4		1			14	6	1	67
Student17		1	8		1			11	22	1	94
Student18			7	1				11	5	4	80
Student19			8		1			10	2	9	72
Student20			2					6	1	1	46
Student21				1				10	2	2	41
Student22		4	2	5				8	0	2	57
2013 ESSAY Task	0	13	83	37	4	0	0	202	92	70	67
No/student	0.0	0.6	3.8	1.7	0.2	0.0	0.0	9.2	4.2	3.2	

TABLE I: HYDRO-ELECTRIC DAM ASSESSMENT TASK CONTENT STATISTICS FOR STUDENTS IN 2014

	VirtualALps 2.0 HEP Task										
	Graphs/Figs drawn	Maps	Diagrams sourced	Photos	Tables compiled	Calculations	Opinions	Journals cited	Books/ Reports cited	Websites cited	FINAL MARK
Student01	5	2	2	2	2	4	1	9	1	7	56
Student02		1	4	1	1	6	1	1	11	1	56
Student03	8	3	13	1	2	5	1	2	6	2	60
Student04	5	1	2	1	4	3	2	20	7	8	81
Student05	1	2	1		1	4	1	19	2	5	70
Student06	1	2	9		1	5	2	12	9		72
Student07	2	1	4	2	1	4	2	10	3	3	65
Student08	4	3	5	3	3	5	1	9	8	4	89
Student09	4	3	2	5	6	4	1	8	8	5	72
Student10	6	3	7	1	4	5	1	13	9	3	72
Student11	7	2	4		2	3	2	20	2	2	82
Student12	6	1	4	2	4	3	2	14	1	10	73
Student13	3	3	2		4	1	2	28	8	6	71
Student14	2	2	7		4	3	3	19	5	2	60
Student15	2		3		5	4	1	11	4	2	54
Student16	5	2	2	2	1	2	1	6	8	3	50
Student17	2	1	3	4		2	1	3	5	10	50
Student18		1	4	1	2		2	7	5	5	51
Student19	3	2	2	2	1	4	3	18	2	4	78
Student20	3	1	3		3	2	1	14	3	2	61
Student21	7	6	9	3	3	5	2	12	8	7	76
2014 HEP Task	76	42	92	30	54	74	33	255	115	91	67
No/student	3.6	2.0	4.4	1.4	2.6	3.5	1.6	12.1	5.5	4.3	

Figure 3 compares the data for the 2013 essay task with the data for the 2014 hydro-electric dam task.

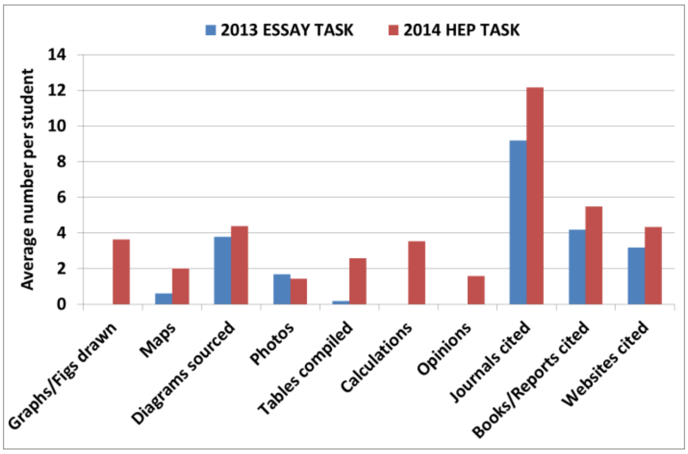

Figure 3: Comparison of 2013 Essay task statistics with 2014 Hydro-Electric Dam assessment task

B. Analysing the changes

Figure 3 shows that the 2014 students' reports on the hydro-electric dam task which required students to use VirtualAlps 2.0 showed increased numbers of all measures except the inclusion of photographs. In particular, 2014 students drew more of their own figures (an average per student of 3.6 v 0.0) and included more of their own calculations (again an average per student of 3.5 v 0.0). This is likely to be because one of the first objectives of the task was to calculate the volume of the proposed dam. Most students tackled this by first drawing the proposed dam and reservoir, then performing volumetric calculations, using their diagram for scale and as an aide to working through the calculations. Some students created tables to organize their calculations and this may explain the greater average number of tables in the 2014 students work (an average per student of 2.6 v 0.2). These skills (drawing interpretive diagrams, performing calculations and creating tables of data) were absent from the 2013 traditional essays. 2014 students also included in their reports more maps (an average per student of 2.0 v 0.6); more diagrams sourced from books/journals (an average per student of 4.4 v 3.8), they cited more journals (an average per student of 12.1 v 9.2), more books/reports (an average per student of 5.5 v 4.2 and more web sites (an average per student of 4.3 v 3.2). One other key difference between the 2014 reports and the 2013 essays was that students expressed more opinions in the 2014 reports (an average per student of 1.6 v 0.0) than in the 2013 essays. This was most likely because the 2014 task required students to make a recommendation about the feasibility of the hydro-electric dam proposal to the Swiss Government. Through this, students were required to express their opinions and to back them up with the data, calculations and evidence which they had gathered in their report.

C. Discussion

What new skills have the students gained ?

Virtual Fieldwork , it has been argued, is ‘likely to fall short of the real fieldtrip experience of learning in the field’ [15, p. 260]. Do VFGs help to develop the necessary professional competences, or rather than helping to build skills, does “Virtual Fieldwork detract from them by allowing students an easier and more comfortable option of viewing data from their homes and classrooms, rather than having to acquire the skills of data collection” [13, p.217].

VFGs are seen by some simply as useful repositories for secondary information sources which represent ‘real’ sites in a variety of ways and which help students through their first experiences of fieldwork. They therefore would situate “towards the lower end of the progressive continuum” [13, p.217] which goes from ‘interactional expertise’– some kind of fluency in the language of the subject but not necessarily associated with competence in practice – to full ‘contributory expertise’ that involves skills in the hands-on practice of the subject [16]. This view would reinforce the idea that traditional VFGs are ‘second best’ to first hand study in the field which would be more authentic. However, in an increasingly technologically focused society, perhaps we need to view the meaning of the term ‘authentic’ differently [13]. In this context, we would argue that VirtualAlps 2.0 engaged students with complex and varied data, some of which would not have been otherwise searchable online because it was from the tutor’s own collection.

Perhaps, we should be less concerned about perceived ‘loss’ of field skills in this task (the students have numerous other opportunities to practice these in a variety of field visits throughout their degree programme anyway) and instead ask what the acquisition of these new skills means for the practice and pedagogy of the geoscience discipline which may be considered to be in a state of flux ?

D. Conclusions

This paper draws on experiences of designing, developing, using and evaluating a semantic web-based Virtual Field Guide (VFG), VirtualAlps 2.0, for teaching level 6 geosciences at Liverpool John Moores University. The VFG employs 'linked data' and 'semantic web' approaches to allow students to access diverse web-based resources, to explore the relations between them, and to then draw on these to prepare a feasibility report for a proposed hydro-electric reservoir and plant in a Swiss Alpine Valley. The VFG provided students with real environmental data, maps, photographs, video and links to relevant research papers which students used make interpretations and draw their conclusions about the feasibility of such a scheme.

Prior to 2013 the assessment task was an essay (1500 words) with the title: “Discuss the impacts of current trends in climate on river flood hazards”. A total of 22 student essays from 2013 were analysed during the marking process and counts were made of the number of: graphs/figures drawn; maps; diagrams sourced; photographs; tables compiled; calculations; opinions expressed; journals cited; books/reports cited; and, websites cited. In 2014 21 student’s reports based on their use of VirtualAlps 2.0 were analysed in the same way.

The 2014 students’ reports on the hydro-electric dam task using VirtualAlps 2.0 showed increased numbers of all measures except the inclusion of photographs. In particular, 2014 students drew more of their own figures, performed more calculations and created more tables to organize their calculations and data. 2014 students also included in their reports more maps; more diagrams sourced from books/journals, they cited more journals, more books/reports and more web sites. The other key difference between the 2014 reports and the 2013 essays was that students expressed more opinions in the 2014 reports. It is argued that while the VirtualAlps 2.0 task may be less ‘authentic’ than a traditional field visit to the site, it gives students new opportunities to work with real environmental and secondary web-based data to tackle real world issues. Geoscience and the world of employment for geoscientists is in a state of flux at present, and the ability to work using linked data and semantic web approaches is now an important skill for graduates to be able to offer.

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